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6/11/82

Note For: John McMahon

07 AUG 1982

John,

I think the attached study might be of interest to you. Good luck in your new job.

Moe Rosen

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L-290

Japanese Competition in the Computer and Semiconductor Industries: How Should the U.S. Respond?

A Case Study by Morris Rosen

Twenty-Fourth Session 1981-82

Executive Seminar in National and International Affairs

United States Department of State
Foreign Service Institute

This study has been prepared as part of the curriculum of the Executive Seminar in National and International Affairs. The views expressed in the study are those of the author; they do not necessarily represent either those of the Foreign Service Institute or of the Department of State.

Approved For Release 2008/07/01 : CIA-RDP83M00914R002200160047-4

JAPANESE COMPETITION

IN THE COMPUTER AND

SEMICONDUCTOR INDUSTRIES:

HOW SHOULD THE U. S. RESPOND?

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Preface

The information in this report is based on the references cited and discussions with individuals as detailed in the Appendix. The remarks of these individuals were meant to be "off the record" and have not been quoted. They did, however, have an extremely important influence on my personal assessments. I greatly appreciate the time these individuals spent with me.

A number of these individuals and some friends from the Intelligence Community Staff also took the time to read drafts of this report. Many thanks to each of them and to Harriette Dowdy, Linda Green, Ethel Fletcher, and Helen Livingston for their superb typing.

Morris Rosen
Executive Seminar in
National and International Affairs
May 1982

EXECUTIVE SUMMARY

U.S. and Japanese Computer and Semiconductor Industries

- High technology industries, such as computers, are especially important to the United States because they support competitiveness in many economic sectors, because they have military significance, and because they are consistent with the role of an advanced economy such as that of the U.S. in the interdependent and rationalized world economy of the future.

- The computer and semiconductor industries have demonstrated remarkable world-wide growth over the past 10 years and are expected to continue that growth through the 1980s. New applications--stimulated by continued rapid advances in technology--will spread throughout the home, the office, the battlefield, and the factory and will revolutionize our society.

- The U.S. industries continue to dominate the world market in sales and technology but the Japanese are increasing their market share; have reached rough equivalency in the performance, quality, and cost of a broad range of products; and are now ahead in certain important segments of the semiconductor market.

- The Japanese drive for dominance in the information industry is a key part of Japan's industrial strategy for the 1980s. The efforts of Japanese industry have been supported by a variety of direct and indirect government measures in the areas of government and industry coordination, technology development, financial assistance, and market protection.

- The prospects for the future are uncertain but continued Japanese advances are likely. The U.S. industries are probably capable of deflecting the near-term challenge but the competitive process will limit profits and at the same time require large investments in both R&D and plants and equipment. As a consequence, if adequate and low cost external capital is not available, the rapid pace of U.S. industry innovation may decline and open the doors for further competitive inroads by the Japanese or others with access to an adequate supply of capital.

Policy Development Process

- The major role in responding to the Japanese challenge will be played by the U.S. computer and semiconductor firms. Government has a clear responsibility in formulating and executing international trade policy and providing a financial and regulatory environment that supports the industry response. Some authors have advocated that the U.S. develop and implement a coherent industrial policy for high technology industries. Others believe that there is little need for significant government intervention in the market and question the ability of government to either reach a consensus on an approach or implement a chosen approach with any effectiveness.

Comment: Steps to support definition of a more coherent industrial policy for high technology industries should be taken. These include creation of a focus in Congress for policies that affect industry, creation of a mechanism for business and public participation in clarifying the goals of industrial policy, creation of an analytical group for examining competitiveness and economic performance, and establishment of a high-level executive group for coordination of industrial policy throughout the government. Greater attention to data collection and analysis--both foreign and domestic--is also needed.

Trade Policies

- Domestic market protection through both formal and informal barriers has been and probably still is a key element in the success of the Japanese computer and semiconductor industries. This protectionism provides a financial cushion that can be used to support foreign market penetration via aggressive pricing. The U.S. computer and semiconductor industry associations oppose protectionism in the U.S. market and support the current U.S. negotiating efforts to open up the Japanese market. Congress is considering new trade legislation that would strengthen the President's hand in the ongoing negotiations by giving him additional authority to take action against nations that are found to be practicing protectionism. The more extreme "reciprocity" bills will probably be rejected and a moderate bill acceptable to the administration is the most likely outcome.

Comment: Changes in the world economy appear to be pushing nations toward greater protectionism through the use of non-tariff barriers. The U.S. should continue bilateral and multilateral efforts to counter this trend and open up protected markets. The President should be given the authority to use remedies consistent with our multilateral trade agreement obligations but he should be given wide latitude in his selection of the appropriate remedy. New trade agreements will require vigorous U.S. enforcement efforts to achieve their purposes. Even so, it is doubtful that these agreements will, by themselves, solve the problem. Policies for enhancing U.S. competitiveness should also be pursued.

- Export promotion is probably of less importance to the computer and semiconductor industries. Measures such as weakening the Foreign Corrupt Practices Act, encouraging Export Trading Companies, increasing the funding of the Export-Import Bank, and weakening export controls have been proposed.

Comment: Increased funding for the EX-IM Bank appears to be the most important of the measures that have been proposed. Weakening of export controls may not be feasible considering the known national security technology transfers that have occurred in recent years.

Manpower Policies

- There is a serious current shortage of high technology manpower--electrical engineers, software engineers, technicians, and skilled production workers--and the gap between the demand and supply is projected to increase. The engineering shortage is primarily due to a lack of resources, especially faculty, at engineering colleges. However, there are also reasons to believe that the supply of qualified college applicants may be inadequate, in part because of the current poor state of science and technology education in secondary schools. The American Electronics Association (AEA) has proposed that its members provide financial and material support to universities to increase faculty and upgrade equipment and facilities in electrical and software engineering.

Comment: Our national future will be vitally affected by whether or not we take steps to improve our educational system for science and technology. It is a national problem and the federal government should take steps to lead and coordinate the efforts of all elements of the educational system--state and local governments, industry, and the private educational institutions--and see to it that federal education expenditures are directed toward supporting that goal. Recommended policy initiatives include:

-- Industry plans (such as that of AEA) to expand engineering educational resources should be carried out. Tax changes to encourage industry to provide such support may be needed.

-- A federal program to encourage state and local governments to improve science and technology education in secondary schools should be implemented. This program might include: measures for increasing public awareness of the need for science and technology education, curricula development programs (including the use of new technologies), measures to promote awareness of career opportunities in science and technology, and measures to alleviate the serious shortage of qualified mathematics and physical science teachers.

-- Cutbacks in student loans and grants should be reviewed and modified if necessary to ensure that qualified undergraduate and graduate science and technology students, and technician trainees are not denied the opportunity to pursue their educational goals.

-- A program of grants or tax incentives to encourage the continuing engineering education of the work force should be developed.

-- Labor adjustment policies (as practiced by the Japanese) that emphasize worker retraining should be considered as another way to address the shortage of technicians and skilled workers. State and local governments and private institutions should be encouraged to improve educational resources in this area.

Tax and Capital Market Policies

- The availability of stable low-cost capital is vital because of the need to respond to continued technological change and rapid growth in markets. The Japanese economy has been able to provide such financing to their industries; the U.S. economy has been deficient in terms of both stability and cost. The administration's 1981 tax program recognized this problem by including provisions to encourage personal savings and investment, and business investment in plants, equipment, and R&D through liberalized depreciation and R&D tax credit. Some authors advocate a sectoral approach to target additional capital for growth industries.

Comment: Targeted tax legislation or loan subsidies aimed at growth sectors may be needed. This issue should be studied.

Research and Development Policies

- Technology, applied to products through R&D, has been the key to U.S. domination of the computer and semiconductor industries. As the result of wide diffusion of U.S. developed technology and vigorous Japanese government-industry efforts, the once huge U.S. technological lead over the Japanese has been lost and the Japanese are at or near technological parity with the U.S. in many segments of the computer and semiconductor industries. If these U.S. industries are to survive the challenge, they must continue to innovate and move technology forward because the Japanese are not likely to be defeated in high-volume production of a slowly changing product. Approaches for supporting R&D include:

  -- Direct Government Funding: The Department of Defense is carrying out a program in applied semiconductor research known as the Very High Speed Intergrated Circuit (VHSIC) program. Basic research is supported by the Defense Advanced Research Projects Agency (DARPA), the Office of Naval Research (ONR) , and the National Science Foundation (NSF). The author is unaware of any programs of direct government funding of R&D directed at commercial applications.

  -- Cooperative R&D and Anti-Trust Policies: In the past few years, firms in the U.S. computer and semiconductor industries have taken steps to follow the Japanese example and form cooperative R&D ventures. A key issue is whether or not such ventures violate U.S. anti-trust laws and, if so, whether legislation to amend these laws is needed.

  -- Patent Policy and the Transfer of Technology: There appear to have been and may still be barriers to the flow of Japanese technology to the U.S. that are inequitable compared to the relatively free flow from the U.S. to Japan. Eliminating these inequalities in the diffusion of technology is a major goal in our bilateral trade negotiations with Japan. Steps to slow the diffusion of technology or increase the rewards to the innovator have been proposed.

  Comment: Direct government funding of commercially directed R&D should be considered. Cooperative R&D appears to be a preferred policy response and should be supported by appropriate government actions, including new anti-trust legislation if that is required. Cooperative U.S. industry action to increase compensation for technology sales should also be considered.

Procurement Policies

- The U.S. Government has no explicit procurement policies to support U.S. computer and semiconductor firms. Policies for industry support through government procurement are likely to be ineffective except in segments where government represents a major share of the market.

Conclusions

- The Japanese challenge to the U.S. information industry is a serious threat to the future well-being of the U.S. Some combination of the responses described here will be required. Government and the private sector should work together to evolve a preferred set of responses.

I. Introduction

In Boston, Massachusetts; San Jose, California; and Charlotte, North Carolina the Executive Seminar heard several themes repeated:

- High technology industries, such as the computer and semiconductor industries, are very important to the future growth of the local economy.
- There is guarded concern about the effect of potential Japanese competition on these industries.
- But, government and industry leadership is confident that the local industries will remain strong and healthy because of the high quality of the production work force, their scientific and engineering personnel, and supporting education institutions.

At the same time, newspapers and popular magazines featured stories on the major challenge posed by Japan's progress in these industries and the uncertain prospects for the U.S. industries. There is clearly a major difference between what we were hearing in the field and what we were reading in the press. It seems vitally important to know who is right and, if there is a major problem, what should be done about it.

In a recent report, the Subcommittee on Trade of the House Ways and Means Committee had this to say about the Japanese challenge: [1]

"We do believe, however:

- that the Japanese challenge is extremely serious, is not fully understood by most Americans, and cannot go unanswered;
- that the nature of the challenge will force some far-reaching changes in management techniques, labor-management relationships, and societal as well as business attitudes toward productivity and quality control;
- that the response to the challenge will be difficult because in addition to all the easy "answers," such as changes in taxes, education, and export promotion, it will require more difficult attitudinal changes and realignment of priorities; and
- that if America responds to the challenge correctly, we can create a better economy for not only ourselves but for the whole world.

Our visit to plants, our discussions and readings, and even more the attitude of the Japanese themselves, clearly show that in the high technology products that count--the products which will dominate the world trade and economy for the rest of this century--the Japanese are second to none. Whether they today surpass the United States in

[1] Report on Trade Mission to Far East, p. 19.

their mastery of these high technology products is debatable; it is not debatable that the trend lines indicate that they will surpass the United States and that the gap will widen dramatically, UNLESS the United states responds.

In the previous two Congresses, the Subcommittee on Trade had a Task Force on U.S.-Japan Trade. In a report dated September 5, 1980, that Task Force said:

> We believe that Japan's rate of industrial progress and stated economic goals should be as shocking to Americans as was Sputnik. And like Sputnik, we should be shocked into responding to the challenge.

We all endorse and reconfirm that statement."

The purpose of this report is to describe the Japanese challenge to the U.S. computer and semiconductor industries and the policy alternatives that the U.S. should consider as a response. The time constraints of this study precluded original in-depth analysis of these policy alternatives. The pertinent conclusions of others have, however, been reported and the author's own conclusions are reported under the heading, "Comment".

II. THE U.S. COMPUTER INDUSTRY

In the past 20 years, the worldwide computer industry has shown remarkable growth in terms of the diversity of products, product performance, applications, sales, and employment. This progress has largely been driven by the technological advances and dynamism of the U.S. computer firms and their worldwide marketing and manufacturing subsidiaries. U.S. industry leadership was maintained in 1981. However, there are disturbing signs that this leadership will be increasingly challenged by the Japanese and the Europeans. The prospects for the U.S. industry are therefore more uncertain now than at any time in recent history.[2]

The computer industry can be described in terms of either products or applications. The products include the more traditional large mainframe systems and their more recent, less expensive, and rapidly growing competitors--the mini-computers and micro-computers. The distinctions between these products are blurring as "today's" microcomputer capability begins to approach that of "yesterday's" mainframes. Computer applications are virtually unbounded but include science and engineering, business (including manufacturing), military, and personal applications. The most rapidly growing applications include manufacturing automation and robotics, office automation, and personal use. Computer networking for sharing computer resources and information exchange is also growing rapidly.[3]

IBM is by far the largest manufacturer of mainframe computers both in the U.S. and worldwide (about 40% of worldwide industry shipments).[4] There are five other major U.S. mainframe computer manufacturers--NCR, Control Data, Sperry, Burroughs, and Honeywell--and a host of more recent industry entrants that have specialized in the mini- and micro-computer markest. These more recent entrants are headed by Digital Equipment Corporation (whose sales volume is now comparable to that of the largest of the other traditional mainframe manufacturers) and include high-growth glamorous stock-market names such as Hewlett-Packard, Data General, Apple, and Wang. In 1981, the micro-computer market grew very rapidly, and the competing firms have struggled to adjust to the dynamism of this new market. The trend toward increased sales of plug-compatible mainframes (those interchangeable with equipment manufactured by IBM) continued and these systems increased their share of the market.[5]

IBM has responded to these challenges by upgrading its line of mainframes, aggressive pricing, a major capacity expansion program, and new products that compete directly in the mini- and micro-computer markets. The five traditional mainframe manufacturers, whose profits have recently been under pressure, thus find themselves scrambling to maintain their market share

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2 Eckelman, p. 72-74; US Industrial Outlook, 1982, p. 223; World Business Weekly, April 20, 1981, ITC Publication 841.
3 See U.S. Industrial Outlook, 1982; Wall Street Transcript, November 1981; ITC Publication 841.
4 ITC Publication 841, p. 7.
5 See World Business Weekly, April 20, 1981; Wall Street Transcript, November 1981; Fortune, January 25, 1982; Financial World, May 15, 1981.

(about 25% in 1980) in the face of aggressive competition from IBM, the plug-compatible manufacturers, the U.S. mini- and micro-manufacturers, and the Japanese and Europeans, who are now attempting to penetrate all segments of the market. At the same time, IBM's reduced rate of earning growth over the past few years continues to disappoint Wall Street, its profit margins have slipped, and for the first time it has had to go into the capital market to finance its recent new-product introductions and capacity expansions.[6]

Industry trends and projections, shown in Table 1, demonstrate the rapid growth of the computer equipment industry but mask the dynamism and problems described in the previous paragraph. For example, the large positive trade balance in computer equipment continued to grow to about $7.2 billion, while export growth slowed and import growth accelerated. The value of exports showed a shift toward a greater percentage of parts over equipment as the buildup of U.S. off-shore assembly facilities continued. Imports of computing equipment and parts grew rapidly in 1981, rising an estimated 38 percent to $1.6 billion. In the case of Japan, the second largest supplier (Canada was the largest supplier), joint marketing ventures between Japanese suppliers and U.S. distributors helped to boost the 1981 level. The strong growth in the U.S. new supply of computer equipment and the proportionally small contribution of imports during the 1978-1980 period stands out in contrast to the other producing nations (see Chart 1). Furthermore, this chart does not portray the full strength of the U.S. computer industry because overseas subsidiaries of U.S. firms contribute significantly to the computer production in each of the five countries.[7]

The computer services industry, a partner of the computer equipment industry, has three major sectors--processing services, professional services, and software products. In 1981, revenues for the industry were estimated to have grown by about 20 percent to $18 billion, while employment increased 12 percent to 343,000 workers through mid-1981.[8]

Future Prospects

In the next five years, the U.S. market--the most mature in the world--will continue very rapid real growth in the newer labor-saving and cost-reduction applications such as robotics, personal computing, office automation, and networking while the traditional large mainframe markets grow at a much slower pace. Continued rapid advances in semiconductor technology will also stimulate increased demand by contributing toward greater performance and limiting cost increases. The market outside the U.S. will grow at an even greater pace with the most growth in the fast-growing maturing economies outside Europe and Japan. Quantitative estimates of these U.S. and world growth rates are not available. However, in then-year dollars, the U.S market grew at a 20 percent rate in the 1978-1981 time period, a period containing two recessions. Currently no trends are seen--barring long recession periods--that would lead to any significant lowering of this growth

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6 Ibid.

7 U.S. Industrial Outlook, 1982, See CBEMA February 18, 1982, Report for detailed 1981 trade data.

8 U.S. Industrial Outlook, 1982, p. 226, 227.

Table 1:

Computing Equipment (SIC 3573): Trends and Projections 1972–82

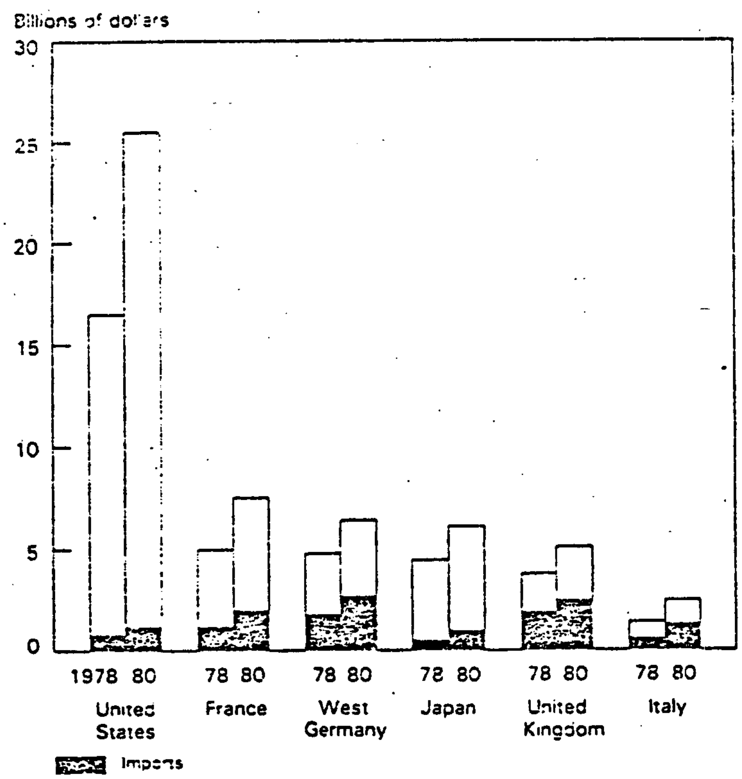
(in millions of dollars except as noted)

Item	1972	1977	1978	1979	1980 [1]	1981 [2]	Compound annual rate of growth 1972–81	1982 [3]	Percent change 1981–82 [3]
Industry data									
Value of shipments [4]	6,471	12,924	16,558	21,466	25,630	30,450	18.8	—	—
Value of shipments (1972 $) [4]	6,471	12,924	16,558	21,466	25,630	29,220 [8]	—	33,600 [8]	15.0
Total employment (000)	145	193	232	274	302	314	9.0	345	10.0
Production workers (000)	65	86	103	122	130	131	8.1	140	7.0
Average hourly earnings of production workers ($)	4.19	5.68	6.26	6.34	6.96	7.90	7.3	8.60	8.9
Capital expenditures	213	652	1,101	1,317	—	—	—	—	—
Product data									
Value of shipments [5]	6,108	12,673	15,769	20,399	24,350	29,000	—	—	—
Value of shipments (1972 $) [5]	6,108	12,673	15,769	20,399	24,350	27,760 [8]	—	31,920 [8]	15.0
Product price index (1972=100)	100.0	100.0	100.0	100.0	100.0	100.0	—	—	—
Trade									
Value of exports	1,341	3,264	4,128	5,389	7,468	8,810	23.3	11,450	30
Value of imports	176 [6]	253 [6]	755	969	1,159	1,600	NA	2,240	40
Export shipments ratio	0.220	0.258	0.262	0.265	0.307	0.304	—	0.307	—
Import new supply ratio [7]	0.028	0.020	0.046	0.045	0.045	0.052	—	0.060	—

[1] Estimated except for product price index, exports, and imports.
[2] Estimated.
[3] Forecast.
[4] Value of all products and services sold by industry SIC 3573.
[5] Value of shipments of computing equipment products produced by all industries.
[6] Does not include parts for computers.
[7] New supply is the sum of product shipments plus imports.
[8] There is no official price index for this industry (see discussion in text), but, based on estimates, the Bureau of Industrial Economics has adjusted these figures for inflation, using 1980 as the base year.

Source: Bureau of the Census and Bureau of Industrial Economics. Estimates and forecasts by the Bureau of Industrial Economics.

Chart 1: **New Supply[1] and Imports of Computing Equipment**



[1]New supply is the sum of product shipments (to both domestic and international customers) plus imports.
Source: Official Government publications of each country.

Source: US Industrial Outlook, 1982, US Department of Commerce rate. Thus, it is not unreasonable to forecast market growth rates (in then-year dollars) of about 20 percent in the U.S. and possibly 20-25 percent outside the U.S. for at least the next five years.[9]

The following trends have been forecast for the 1980s:[10]

- The increasing interdependence of computers and telecommunications will continue the trend toward greater diversity in the computer equipment industry, creating additional market opportunities for both new and established firms.[11]

- Hardware costs will continue to comprise a declining share of overall data processing costs.

- The greatest growth in sales will take place at the low end of the market--in the booming areas of personal, micro- and mini-computers.[12]

- A gradual blurring of traditional distinctions between industries, e.g., computers and telecommunications, will continue.

- National attempts to develop high-technology computer capabilities will become more frequent.

The anticipated market and technology developments imply:[13]*

- U.S. Market Share: The overwhelming U.S. world market share of about 80 percent will inevitably deteriorate as European and Japanese firms increase their market shares in their domestic markets and compete vigorously in the U.S. market and the high-growth third world markets. The penetration in the U.S. and European markets will continue to be largely at the small end of the market.

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9 U.S. Industrial Outlook, 1982; Wall Street Transcript, November 1981.
10 Eckelman, p. 75-76, except as noted.
11 U.S. Industrial Outlook, 1982, p. 227.
12 Minicomputer market growth forecast at 25-35%; personal computer market growth forecast at 40%; Wall Street Transcript, November 1981.
13 Eckelman, p. 77-79; U.S. Industrial Outlook, 1982, p. 227.

* Market share is based on the ownership of the firm. Imports and exports are based on the location of the manufacturing facility, regardless of ownership. Imports from a U.S.-owned manufacturing facility would be included in the figures for U.S. imports and might tend to overstate the extent of foreign penetration of the U.S. market. Similarly, foreign-owned marketing within the United States would not be included in the figures for U.S. imports and would tend to understate the extent of foreign penetration of the U.S. market. Estimates for market share, imports, and exports must therefore be examined carefully to determine the underlying trends.

- U.S. Exports: Exports will continue to grow as a percentage of U.S. industry shipments as overseas manufacturing subsidiaries continue to grow in importance.

- U.S. Imports: Imports will similarly continue to grow as a percentage of U.S. apparent consumption. A large part of this growth will be related to the use of overseas manufacturing subsidiaries by U.S. firms.

Factors that may restrict both U.S. domestic and worldwide industry growth are protectionist practices of foreign governments and growing competition from foreign firms, particularly the Japanese. The current Japanese share of the world market is about 6-7 percent[14] and their share of the U.S. market (from imports) is about 2 percent[15]. Japan's Ministry of International Trade and Industry (MITI) has announced a goal of capturing 30 percent of the world market and 18 percent of the U.S. market by the end of the 1980s.[16]

14 Eckelman, p. 77.
15 Imports: $387 million based on CBEMA, February 18, 1982; Aparent Consumption: $21.8 billion based on U.S. Industrial Outlook, 1982.
16 Business Week, December 14, 1981.

III. THE JAPANESE COMPUTER INDUSTRY

The Japanese computer industry, which has recently become roughly equivalent to the U.S. industry in terms of product performance, cost, and quality, is now poised to challenge the U.S. industry across a broad range of products and markets.

There are five major Japanese computer manufacturers: Fujitsu, Hitachi, Nippon Electric (NEC), Toshiba, and Mitsubishi; and at least 50 or 60 makers of small business computers. Fujitsu is the largest in terms of computer sales but the smallest in terms of overall sales. In FY 1979 (year ending April 1980), Fujitsu's sales were about $1.6 billion, approximately 23 percent of the Japanese market. In that same year, Hitachi and Nippon Electric, the next largest firms, had much smaller shares of the Japanese market--about 15 percent.[17] The computer sales of the Japanese firms are thus much smaller than those of IBM and comparable to but generally smaller than those of the five major U.S. mainframe firms. The manufacture of computers is Fujitsu's main line of business; the other four major firms are largely diversified manufacturers with computer manufacturing revenues representing a relatively small percentage of sales. Except for Toshiba, which is focusing on small business computers, the major Japanese computer manufacturers have products that compete with IBM across the full range of mainframe performance (see Chart 2). Furthermore, except for NEC, each of these manufacturers has established plug compatibility with IBM so that users can buy Japanese computers but still run IBM software. Each of the Japanese firms has (or soon will) set up joint ventures and subsidiaries (some wholly owned) in the U.S, Europe, and other parts of the world for the sales, service and assembly of their products. The Japanese recognize that consistent sales and service organizations must be established before they can enter a market, and they have been careful not to enter prematurely.[18]

Industry trends, shown in Table 2, demonstrate the rapid growth of the Japanese industry[19]. During this period, exports as a percentage of apparent consumption increased while imports as a percentage of apparent consumption declined. The market share held by U.S.-owned firms such as IBM-Japan also declined during this period.

Table 2

Japan's Production of Computers and Computer Equipment
(Dollars in Billions)

1976	1977	1978	1979	1980
2.73	3.17	4.01	4.96	5.71

Compound Growth Rate: 20 percent

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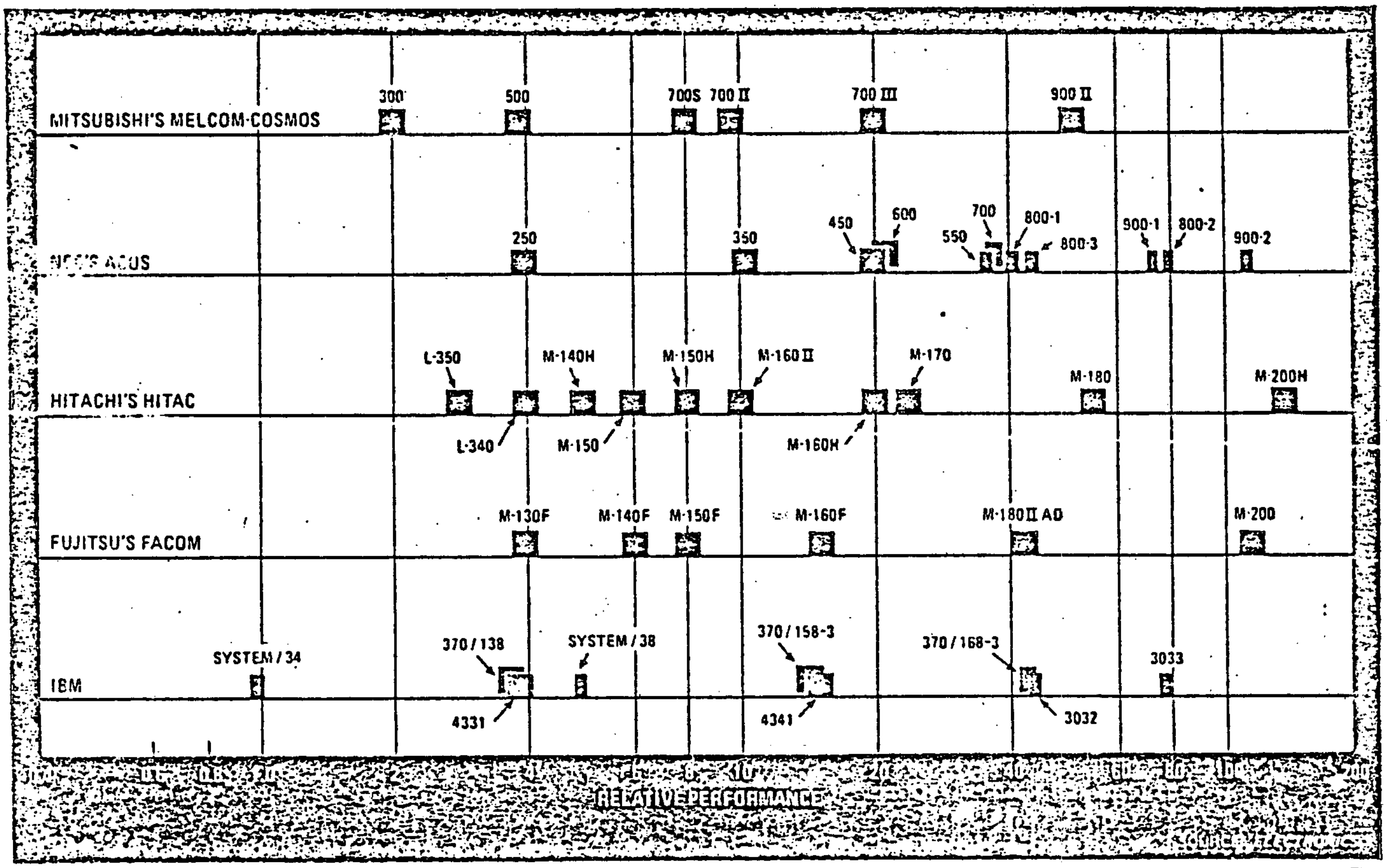
17 Business Week, April 6, 1981.
18 Electronics, March 27, 1980.
19 Commerce Department, Bureau of Industrial Economics figures based on MITI statistics converted to U.S. dollars using 1980 exchange rate of 226.75 Yen = $1. for all years.

Chart 2

Japanese Mainframe Capabilities Compared to IBM's



10. Competitive. The four major Japanese mainframe computer lines illustrate how competitive the country's technology has become. The manufacturers, now independent of imported technology, compete head to head with IBM, which sets the *de facto* industry standard.

Source: Electronics
March 27, 1980

Approved For Release 2008/07/01 : CIA-RDP83M00914R002200160047-4

Future Prospects

MITI has set a national goal of winning a worldwide market share of 30 percent and a U.S. market share of 18 percent by 1990.[20] There are few observers that have thus far cited this goal as an unrealistic one. In fact, Professor Michael Dertouzos, Director of MIT's Computer Sciences Laboratory and a White House technology planning advisor, is reported to have gone much beyond this with the general warning that "It is almost inevitable that by 1990 the Japanese will achieve in computers what they have already done in automobiles--unless American hardware manufacturers remove their 'long-term blinders' and the U.S. government assists the DP industry with investment credits and tax incentives."[21]

The Japanese are expected to be successful in achieving their goals for the following reasons:

- The adequacy of their current products in terms of price, performance and quality.
- Their long-term financial support which will enable them to price their products aggressively to win market share.
- Government support in the form of R&D and tax incentives.
- Their growing capability in the all-important area of computer-related semiconductor technology and manufacturing.
- Their ability to dominate their protected home market, the second largest in the world.
- Their methodical approaches toward setting up indigenous sales and services organizations, and cooperative arrangements with local firms.

In the near term, Japanese firms are expected to continue ther current strategy:[22]

- Target the U.S. market with emphasis on peripherals and the rapidly growing segments such as personal computers.
- Place special emphasis on the less-developed countries and offer deep discounts to increase market share. (This marketing approach is reported to have initially worked well in Spain, Brazil and Australia because IBM was reluctant to deviate from its traditional policy of refusing to give customers a significant price break. However, there are more recent reports that IBM has modified its policy on price cuts in Australia and that Brazil may be unhappy with its arrangement with Japan.)

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20 Business Week, December 14, 1981.
21 Computerworld, May 25, 1981.
22 Business Week, December 14, 1981; Bureau of Industrial Economics.

By employing this strategy, they are expected to slowly build market share and consumer confidence while they steadily improve the competitiveness of their products and service.

IV. THE U.S. SEMICONDUCTOR INDUSTRY

The U.S. semiconductor industry, which has also been dynamic and successful, provides vital components to the computer industry and a host of other industries such as consumer electronic, automobiles, and industrial machinery. The Japanese challenge to the U.S. semiconductor industry has been much more successful than its challenge to the U.S. computer industry. In part, because of the demonstrated Japanese success, both the U.S. and Japanese industry have been studied in depth. The purpose of the recent studies has been to understand better the reasons for the recent Japanese success relative to the U.S. in order to uncover appropriate actions that might be taken to restore the U.S. industry to its previous pre-eminent position.[23]

Semiconductor products include discrete devices and integrated circuits (ICs) with the latter further broken into analog devices, digital logic devices, and digital memory devices. In 1980, digital devices--the most rapidly growing segment--represented about 60 percent of the worldwide sales of U.S.-based companies. End use worldwide sales in 1979 can be broken down as follows:[24]

Consumer - 25 percent (automotive, entertainment, personal)

Computer - 28 percent (mainframes, peripheral, office, and Original Equipment Manufacturers)

Industrial and Instrumentation - 23 percent (laboratory, test control and measurement)

Communications - 13 percent (telecommunications, transmission and two-way radio)

Government - 11 percent (military and government special purposes)

A distinction is usually made between "merchant" semiconductor sales and captive production. "Merchant" sales are those sales made to users outside the firm. Captive production refers to the use of the semiconductors produced by the firm in manufacturing its own end-use equipment. Two examples of firms that manufacture semiconductors for in-house use only are IBM and Western Electric. Leading merchant producers include firms such as Texas Instruments and Motorola that produce for both merchant and captive uses, and firms such as Fairchild, National Semiconductor, and Intel that produce almost entirely for merchant sales. In the 1970s, some semiconductor manufacturers attempted to integrate forward into consumer products such as calculators and watches. Recently, there have also been attempts to integrate forward into systems such as small business computers and data-base management and transaction systems. At the same time, an increasing number of computer manufacturers have been integrating backward into selected areas of semiconducter production. The U.S. semiconductor industry also has a large number of

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[23] Zysman, Market Conditions and International Trade in Semiconductors, ITC Report No. 1013.

[24] Zysman, p. 19.

relatively small firms. The industry structure has changed radically over the past two decades as older firms have faded or failed and new firms have been established, some as recently as 1981. The pressure of Japanese competition and the need for larger amounts of investment capital to bring out the next generation of products is currently stimulating a wave of mergers, acquisitions and new starts.[25]

Industry trends, Table 3, show the growth in integrated circuit production by producing region over the period from 1978 to 1981.[26] For a subset of U.S.-based firms over the period 1978-1980, the sales of discrete devices relative to that of integrated circuits varied from about 49 percent in 1978 to about 32 percent in 1980.[27] Thus, total worldwide semiconductor sales are probably at least 30 percent higher than shown and growing at a somewhat slower rate. According to Table 3, worldwide IC production grew in dollar value by about 28 percent/year over the period 1978 to 1981, while U.S.-based merchant and captive production each increased by about 30 percent/year. However, the growth from 1980 to 1981 is only 11 percent worldwide. The Japanese growth rate has been higher than that of the U.S.; the growth rate in Europe and the rest of the world has been lower. Selected information on trade in semiconductor is shown in Table 4.[28] The large share of domestic consumption taken by imports is deceptive since a large percentage of the imports represents the return of a product exported by a U.S. firm for overseas assembly by a subsidiary. In 1978, for example, about 45 percent of the import value of integrated circuits was in this category.[29]

Semiconductor technology has been advancing rapidly in many areas. Semiconductor memory devices, which began with 64 bit devices in 1968, can now store 65,536 (64K) bits of information on a tiny chip and the industry is working on one that will store four times as much (256K bits).[30] Microprocessors have gone through similar technological improvements in terms of speed and complexity. Until recently, the U.S. industry led the world in the development and application of this technology. The Japanese, however, have mounted a major challenge and are now judged to be equivalent to the U.S. industry in digital memory devices, and they may be ahead in the area of quality control. The U.S. industry is still believed to be ahead in the areas of computer aided design and microprocessor design. The growing complexity of semiconductor devices has greatly increased the capital requirements of the industry both for R&D and new plant and equipment. The industry's profitability declined in 1981, in part because of the pressure of Japanese competition. The industry is concerned that they will be unable to generate the capital required to continue technological advances into the 1980s.[31]

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25 Zysman.
26 Ibid., p. 123.
27 SIA Yearbook, Table, p. 15.
28 OTA, p. 52.
29 ITC Report No. 1016, p. 96.
30 Market Conditions . . . in Semiconductors, p. 91-94., Business Week, December 14, 1981, p.61.
31 See Zysman, Chapter III; OTA, p. 84-88; and Bureau of Industrial Economics.

Table 3

WORLD IC PRODUCTION
(millions of dollars)

Producing Region	1978[a]	1979[b]	1980[c]	1981[d]
U.S.				
IC Merchant	3,238	4,071	6,360	7,000
IC Captive	1,344	2,010	2,695	3,050
IC Total U.S.	4,582	6,681	9,055	10,050
Western Europe				
IC TOTAL	453	600	710	765
Japan				
IC Total	1,195	1,750	2,580	2,970
Rest of World				
IC Total	782	675	740	835
Total ICs	7,012	9,706	13,085	14,620

SOURCE:
a) ICE, STATUS 1980, p. 4.
b) ICE, STATUS 1981, p. 2.
c) Figures after November 1980 estimated
d) Estimated for year

Table 4 –Domestic Consumption and Foreign Trade in Semiconductors (millions of dollars)

Year	Domestic shipments	Exports[a]	Imports[a]	Domestic consumption	Exports as % of production	Imports as % of production
1968	$1,415	$ 204	$ 72	$1,283	14%	6%
1970	1,720	417	157	1,460	24	11
1972	1,848	470	330	1,708	25	19
1974	3,646	1,247	961	3,360	34	29
1975	3,002	1,053	803	2,752	35	29
1976	4,310	1,400	1,107	4,019	32	28
1977	4,363	1,497	1,352	4,218	34	32
1978	5,312	1,528	1,680	5,464	29	31
1979	6,852	2,065	2,266	7,053	30	32

[a]Both exports and imports include semiconductors exported for further processing and then reimported. Such devices, usually shipped between divisions of the same company, appear both as exports and as imports.

SOURCES: *1968-72—A Report on the Semiconductor Industry* (Washington, D.C.: Department of Commerce, Industry and Trade Administration, September 1979).
1974-79—Electronics Market Data Book 1980 (Washington, D.C.: Electronics Industries Association, 1980), pp. 104 and 113.

Japanese competition is especially strong in the area of Metal Oxide Semiconductor (MOS) computer memory, an area that is important because of the high volumes of production. (In 1981, MOS memory accounted for 17% of U.S. industry shipments.) In recent testimony to Congress, Alexander Lidow (representing the Semiconductor Industry Association) testified that, "The Japanese industry holds 42% of the 16K dynamic RAM (random access memory) market and over 70% of the 64K dynamic RAM market. These large memory circuits are the 'flagships' of semiconductor technology. Moreover, because they are growing at over three times the rate of all semiconductors, sustained leadership in these commodity products will mean long term market leadership."[32]

Future Prospects

The market for semiconductors is expected to continue its fast growth. The Semiconductor Industry Association (SIA) projects worldwide shipments to grow from $16.1 billion in 1980 to $55 billion by 1990, a compound annual growth rate of about 13 percent. Most of the growth is expected to be in integrated circuits.

The prospects for the U.S. firms in the industry are less certain. The Semiconductor Industry Association has also projected net product shipments through 1984 of U.S. and European-based companies excluding IBM, Western Electric, and General Motors. They assume that military, telecommunications, cable TV and consumer sectors will continue strong growth while industrial and computer sectors will remain flat to slightly up. The worldwide sales of these companies is projected to increase from $9.33 billion in 1981 to $16.7 billion in 1984, a 21 percent rate of increase. Growth is highest in the U.S. and lowest in Europe. The fastest growing product classification is Digital MOS memory chips, growing at a 34 percent compound annual rate.[33]

If the Japanese continue to dominate the 16K and 64K memory markets in the U.S. (and by implication worldwide) and can improve their profitability, they may be able to use this advantage as leverage for catching up in other product clasifications as well. If this has not been assumed by the Semiconductor Industry Association, their forecast for U.S. and European firms may well be on the optimistic side.

[32] Lidow, p. 2. Bureau of Industrial Economics estimates that the Japanese market share of 64K RAMs is at most 65-70%.
[33] SIA Forecast for 1982-1984.

V. THE JAPANESE SEMICONDUCTOR INDUSTRY

As discussed in the previous section, the Japanese Semiconductor Industry has been growing faster than that of the U.S., and has now caught up to and may be about to surpass the U.S. industry in some industry segments that are not changing rapidly. Selected information on industry shipments and trade is shown in Table 5. The following trends are noteworthy:

- The Japanese apparent consumption (AC) of ICs grew at 21 percent/year over the 1976-1980 timeframe. Japanese shipments of ICs may have grown even more rapidly, at an apparent rate of about 40 percent/year.

- Japanese exports to the U.S., primarily ICs, have grown rapidly since 1977, reaching $295 million in 1980. This, however, was a very small share of U.S. shipments (about 5 percent of the total U.S. merchant shipments).

- Japanese imports of ICs have risen in absolute terms but have declined as a percentage of apparent consumption. In 1980, total imports had declined to 22 percent of AC, while imports from the U.S. had declined to 15 percent of AC.

The dominant Japanese firms in the semiconductor industry are NEC, Hitachi, Fujitsu, Toshiba, Mitsubishi, and Matsushita (see Table 6).[34] In 1979, these firms accounted for 79 percent of total Japanese production. In contrast to the U.S. industry, Japanese production is concentrated in a smaller number of firms, with each primarily a manufacturer of systems rather than semiconductors. However, in their recent report for the Joint Economic Committee, Zysman, Borrus, and Millstein point out that internal consumption of their captive production is relatively low, trade is high, and component specialization occurs. They believe that these factors permit the Japanese firms to "control the share and composition of imports entering their domestic market."[35]

Future Prospects

The Japanese market for semiconductors is expected to continue its rapid growth and because of Japanese concentration on the computer industry, consumer electronics, and industrial automation, this growth rate could well exceed the projected 13 percent worldwide growth rate.

The Japanese strategy will be to consolidate their dominance of their own market while expanding their exports to the much larger U.S. market and the European market. To forestall domestic U.S. pressures for industry protection, they will seek to continue their attempts to acquire or set up facilities for manufacturing semiconductors in the U.S.

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[34] Zysman, p. 67.
[35] Zysman, p. 65-72.

Table 5

JAPANESE SEMICONDUCTOR INDUSTRY
(In Millions of Dollars Except as Noted)

	1976	1977	1978	1979	1980	1981
Shipments						
Semiconductors, Total[1]	1530	1770	2400	?	3600	
ICs	663[2]	757[2]	1340[2,5]	1750[3]	2580[3]	2970[3]
Exports						
Semiconductors, Total[2]	392	435	636			
Semiconductors to U.S.	56-80[2]	83-98[2]	134-152[2,7]	240[6]	375[6]	360[6]
Semiconductors To U.S. (% AC)	1.5-2.1	1.8-2.0	2.6-2.9			
ICs to U.S.[6]		40	85	175	295	260
Imports						
Semiconductors, Total[2]	312	294	361			
Semiconductors from U.S.	87-161[2]	76-158[2]	105-207[2]	165[6]	150[6]	295[6]
Semiconductors from U.S. (% AC)	6-11.1	5.7-9.7	4.6-9.0			
ICs, Total[4]	74	64	68	111	118	
ICs, Total (% AC)[4]	29	26	22	27	22	
ICs from U.S.		55[6]	75[6]	135[6]	115[6]	120[6]
ICs from U.S.(% AC)	19.0	17.1	14.4	17.9	14.8	
Apparent Consumption						
Semiconductors[2]	1448	1631	2293			
ICs[4]	840	1088	1330	2015		
Exchange Rate (Yen/Dollar)	300	250	230	200		210

1 Gresser, p. 19
2 Gresser, p. 31
3 Zysman, p. 123
4 Zysman, p. 71 (Converted to dollars based on above listed exchange rate.)
5 1195 according to Zysman, p. 123
6 Semiconductor Industry Association
7 135 according to SIA

Table 6

DOMINANT FIRMS IN JAPANESE SEMICONDUCTOR (SC) INDUSTRY
(1979 sales, 1981 sales in parentheses)

Firm	Total Sales	SC Sales	SC Sales / Total Sales	SC Strength	Systems Market
NEC	$3.3 bil	$590 mil (1200)	17.8%	MOS-LSI (NMOS, CMOS) Memory (16K strong, 64K redesign strong) MPU's (4-bit) Linear	Leading IC powerhouse Leader in Telcommunications Computers
Hitachi	10.7 bil	440 mil (1000)	4.1%	MOS - LSI (CMOS, NMOS) Memory (16K, 64K very Bipolar logic - ECL, Shotky-TTL MPU (Motorola)	Leading Diversified systems computers, producer in communications, consumer, heavy industrial, and electrical machinery
Fujitsi	1.8 bil	120 mil (600)	6.7%	MOS memory (NMOS) (64K strong) Bipolar logic - ECL	Leader in computers
Toshiba	7.1 bil	390 mil (800)	5.5%	CMOS, MSI-LSI (16K static) (64K) Consumer linear CMOS-MPU SOS (recent investment)	Diversified systems, esp. consumer, bus. systems, instrumentation, appliances, and electrical equipment
Mitsubishi	3.9 bil	150 mil (400)	3.8%	Industrial/consumer linear 64K RAM entrant some ECL	Diversified systems, small bus. computers, industrial & heavy electrical equip., medium appliances
Matsushita	9.8 bil	125 mil (600)	2.3%	Consumer linear new 64K static RAM (strategy shift)	Leader in Consumer & appliances, home computers

Some industry observers fear that the Japanese will come to dominate the semiconductor market much as they have dominated some segments of the consumer electronics market. Others believe that the Japanese have yet to prove that they can match the U.S. in innovation and, until they are able to do that, they will remain formidable but inferior competitors. The outcome is clearly uncertain and will, in part, depend on how U.S. and Japanese government policies develop.[36]

[36] Business Week, December 14, 1981, p. 64.

VI. JAPANESE INDUSTRIAL POLICY IN THE COMPUTER AND SEMICONDUCTOR INDUSTRIES

Japanese success in the Computer and Semiconductor Industries is not an accident. It follows directly from a long-standing commitment to this goal on the part of Japanese industrial policy. Many authors have recently examined this topic and have described and analyzed the approaches followed by the Japanese. A short summary of the principal findings of these studies follow below.

High technology, in general, and the computer industry (including semiconductors, components, and manufacturing equipment) in particular are currently the keys to Japan's industrial master plan as defined in the July 1979 Report of the Ministry of Industrial Trade and Industry (MITI), "Draft Trade and Industrial Vision for the 1980's." Japanese interest in the computer industry goes back to the early 1950s, but intensified greatly after the oil crisis of the mid-1970s. The reasons for Japanese emphasis on the computer industry include:[37]

- High value-added per unit of output.
- High projected growth in the world and domestic market.
- Potential for improving their trade balance in manufacturing.
- Minimal environmental consequences and need for energy.
- Comparative advantage over LDCs because of importance of complex technological capabilities, training, and education.
- Supports productivity enhancing automation across all mature sectors of the economy.
- Supports Japanese penetration into new industries such as telecommunications, aircraft and aerospace, ocean development, and biological engineering.
- Means for enhancing the quality of life by improving delivery of services such as medical care.

The Japanese have chosen to foster the development of the computer and semiconductor industries by evolving an industrial policy structure and a series of government-industry programs that direct this policy framework towards specific developmental objectives. These measures fall into four broad areas: (1) government and industry coordination; (2) technology development; (3) financial assistance; and (4) market protection.

37 See Eckelman, and Gresser.

Government and Industry Coordination (Methods for Influencing Investment Rate and Structure of Producers)

"The Japanese government has combined carrots of fiscal incentives and protection during infant industry stages with sticks of continuing pressures on Japanese industry to rationalize production through mergers, technical upgrading of production methods, retraining of industrial workers, and a variety of other programs. A high degree of cooperation and consultation among government, industry, and the banking community helps to define common objectives in particular sectors and in the formulation of consensual actions." The government industry relationship can be characterized as a participating partnership, based upon pragmatic considerations and mutual respect, working for generally agreed goals. The relationship typically has been referred to as Japan, Inc., but it should be thought of as a giant decentralized multidivisional corporation with largely autonomous subdivisions competing to maximize their own profitability rather than an autocratically directed firm with rigid top-management control.[38]

The key government agencies are the Ministry of Finance (MOF), and the Ministry of International Trade and Industry (MITI). The MOF sets monetary and fiscal policies and controls the government's budgeting and tax collection operations. MITI, the most important institution, has been assigned responsibility for:[39]

(i) shaping the structure of industry and adjusting dislocations that arise in transition;

(ii) guiding the healthy development of industries and their production and distribution activities;

(iii) managing Japan's foreign trade and its commercial relations;

(iv) ensuring adequate raw materials and energy flows to industry; and

(v) managing particular areas such as small business, patents, industrial technology, etc.

The MOF and MITI are the center of a web of organizations that influence government policy, including business management associations, industry associations, and city banks. The business management associations attempt to influence government policy in broad issues of interest to business by framing questions, doing research, conducting debate, and reaching decisions as part of a consensus building process. Industry associations are concerned with policy toward individual sectors and put forward proposals for MITI policy toward an industry as well as implement policies that are adopted (including the establishment of cartels for specific purposes and limited duration). The city banks, which extend one quarter of all loans and discounts in Japan, are

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38 Baranson
39 Magaziner & Hout, p. 33

linked to the MOF through the Bank of Japan. The MOF can and occasionally does exert considerable leverage over the banks to support the established industrial policy.

In computers, MITI has "tried unsuccessfully to rationalise the industry itself through mergers. The companies have preferred to remain independent and a system has emerged in which there is co-operation in the funding of new technology projects, rationalisation and concurrent specialisation in peripherals, but continued fierce competition in existing products and in the production and marketing of new products."[40] On the other hand, the array of measures further described below have clearly served to increase the investment rate in the computer industry and MITI has clearly been successful in providing "an all-important sense of direction to the computer industry as a whole."[41]

Technology Development

The government's own research and development effort is small, in part because the Japanese have been so successful in exploiting foreign basic research and in part because research projects are performed by working groups of corporations under government management. Government means of support for industry R&D include tax credits, grants, and loans. The tax incentives for technology development include:

- 25 percent of all year-to-year increases in R&D expenditures up to 10 percent of total taxable income.
- Accelerated depreciation: one-third of the initial book value of facilities used in production of MITI-approved "newly developed technologies" is permitted as an additional first year write-off. (This can often mean a 60 percent write-off in the first year.)
- Lower tax rate on income from technology licensed overseas.
- Reserve account established to cover up to 50 percent of anticipated software development cost.

MITI has tried to use government grants to rationalize the industry's R&D effort through a variety of cooperative programs. The major grant programs (see Table 7) amounted to about 140 B¥ (approximately $600 million) through FY 1979 and were running at an annual rate of about $80 million in Fy 1979. The projections for the next decade show that this annual spending rate will probably continue to be maintained. The amount of government grants for R&D was about 20 percent of industry's total in 1976 but is reported to be only 11 percent now.[42] The Japanese industry's total R&D spending has been much less than that of the United States. However, it may have been more effective because:

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[40] Ibid, p. 83
[41] Eckelman, p. 99
[42] See Magaziner & Hout, p. 82, for the 1976 figure. See Okamatra, p. 28 for the current figure.

Table 7

(Billions Yen Except as Noted)

	Term	FY 79	Total Thru 79	FY 80	Total	FY 81 & Beyond	Rate (Bil Yen/Year)	Ref.
Very Large Scale Integration (VLSI) Development	76-79	7	29	-	29	-		a, b, c
Pattern Information Processing System (PIPS)	Thru 80	3	20	2	22	-		a, b, c
Information Technology Promotion Agency (IPA) Operation (Software)	71-Indef.	1.5	9.5	2	?	2 (1) Year	2	a, b, c
Next Generation Computer Development	Thru 83	2	2	6	23.5	15.5	5	b, c
Optical Electronic Applied Measure & Control	Thru 86	0.1	0.1	1	20	19 (1)	3	a, c
3.75 Series Computer	Thru 76	-	69	-	69	-		a, b
Software Production Technology	76-81	2	4	1.5 (1)	7	1.5 (1)	1.5	a, b
IC Development	73-74	-	5	-	5	-		a
Software Module Development	73 75	-	4	-	4	-		a
Ongoing Projects Total (3)		16	143	12.5	179.5	36 (2)	5-11.5 (4)	
5th Generation Computer System (In Planning)	81-90	-	-	-	\$500 M	\$500 M	\$50 M	a
Scientific Processor (Super)	81-88	-	-	-	\$112 M	\$112 M	\$14 M/Yr	a
Semiconductor Devices	81-91	-	-	-	25	25	\$10 M/Yr	c
Opt - IC Development	81-91	-	-	-	?	?	?	a
Software Maintenance Technical Development	81-85				\$24 M	\$24 M	\$5 M/Yr	a
New Projects - Total (3)					\$700 M	\$700 M	\$80 M/Yr (5)	

(1)-Estimated (2)-Excludes IPA (3)-Rounded (4)-5 BY, 83-86 (5)-Excludes Opt-IC Development
a-Zysman, P. 132 b-Gresher, P. 17 c-Eckelman, P. 96, 97

- The Japanese industry was behind that of the U.S. and was primarily investing to catch up to the state-of-the-art rather than advance it. (U.S. technology and patents were generally available.)

- Governments's coordination of the cooperative R&D efforts have helped to reduce waste and duplication.

In the past, "hojokin" loans (repayable if and when the particular program results in a profit) were an important financial source for the industry. However, recent changes have included a movement toward more standard loans at modest rates with government guarantees. Only in the software R&D area does a major loan-financing program appear to be in place.[43]

IPA Software Loans
(Billion Yen)

Source	FY 1979	FY 1980	FY 1971-1980
IPA Trust Fund	?	2	150
Long-Term Credit Bank	7	5	

Financial Assistance

The major elements of support include financial assistance for purchasers of computers and specialized tax provisions that benefit the industry. The Japan Electronic Computer Corporation (JECC) is a joint venture of Japanese computer manufacturers, financed heavily by the Japan Development Bank, that purchases computers from the manufacturers and then leases them to customers at competitive (subsidized) rates. The loans to JECC over the FY 1971-1980 time period total about 400 Billion Yen; in FY 1980, loans to the JECC were 48 Billion Yen.[44]

Tax provisions that benefit the industry (in addition to those for R&D discussed in the previous section) include:[45]

- Reserve fund to protect against losses "caused by return of computers" from JECC.

- 20 percent of all year-to-year increases in training costs for software engineers.

- Reserve account for program warranty systems.

Tax provisions for computer purchases have also stimulated domestic demand:[46]

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43 Eckelman, p. 97, 106.
44 Ibid, p. 93, 97.
45 Ibid. p. 98.
46 Ibid. p. 99.

- Accelerated depreciation: 13 percent additional first year write-off is permitted for computers.

- 20 percent of total computer purchases can be deducted for purposes of local asset tax valuation.

Market Protection

"Finally, the Japanese Government deployed its trade policy to serve its larger industrial objectives. Foreign penetration of the home market was managed at least until 1976 with high tariffs, quotas, and registration requirements, merger policy and other controls on direct foreign investment, customs practices and procedures, 'buy-Japan' and other exclusionary policies and practices (such as NTT's procurement policies), and administrative guidance of pricing and the diffusion of technology."[47]

At present, however, the private sector computer market (50-60 percent Japanese market share) is essentially open whereas informal protection continues in the public sector market (over 90 percent market share).[48]

In the semiconductor area, government purchases are confined to domestic producers and, for different reasons, much of the private market is closed to foreign suppliers.[49] Japanese market protection practices prior to 1975 have been extensively discussed by Zysman,[50] and the Japanese government has been characterized as an "official doorman (between domestic Japanese society and the international area) determining what and, and under what conditions, capital, technology and manufactured products enter and leave Japan." Specific measures include:[51]

- Government rejected all applications for wholly-owned subsidiaries and joint ventures with majority ownership by foreign firms and restricted foreign purchases of equity in Japanese semiconductor firms.

- Imports were limited by high tariffs, restrictive quotas, approval-registration requirements, and exclusionary customs procedures.

- Buy Japanese procurement policies, both formal and informal, were implemented.

- Technology imports were controlled by MITI in order to force foreign firms whenever possible to sell technology and to be content with royalty payments rather than product sales.

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47 Gresser, p. 18
48 Magaziner & Hout, p. 86
49 Ibid, p. 86
50 Pempel, p. 139
51 Zysman.

Since 1975, many of the formal restrictions on sales and direct investment by foreign companies have been eliminated. Nevertheless, access to the Japanese market remains very difficult for foreign producers. Zysman writes that:

> "In short, we suggest that collaborative actions of the major Japanese firms may now enable them to take over the role of doorman, played so effectively by the state in other industries and in their own industry's early development."[52]

Evidence cited includes:

- The inability of U.S firms to maintain the share of the Japanese market that they had obtained with advanced product innovations that Japanese firms were not yet producing.

- The extensive trade between the major Japanese semiconductor firms representing a pattern of convenient specialization which more readily permits each company the volumes it needs.

Summary

Without doubt, the above programs, incentives, and other measures have together contributed to Japan's successes. Yet, it is hard to identify which measures (or class of measures) have been most decisive. It is all too easy to credit subsidies for the success of the Japanese industry but subsidies have been relatively modest. Indeed, financial incentives are only one, albeit an important, class of tools deployed to enhance the competitiveness of an industry.

52 Zysman, p. 70.

VII. THE PROBLEM

The previous sections have described the US and Japanese computer and semiconductor industries and how the Japanese industries have been influenced by Japanese industrial policy. The principal findings can be summarized as follows:

- The computer and semiconducter industries have demonstrated remarkable world-wide growth over the past 10 years and are expected to continue that growth through the 1980s. New applications--stimulated by continued rapid advances in technology--will spread throughout the home, the office, the battlefield, and the factory and will revolutionize our society.

- The U.S. industries continue to dominate the world market in sales and technology but the Japanese are increasing their market share; have reached rough equivalency in the performance, quality and cost of a broad range of products; and are now ahead in production and quality in certain important segments of the semiconductor market.

- The Japanese drive for dominance in the information industry is a key part of Japan's industrial strategy for the 1980s. The efforts of Japanese industry have been supported by a variety of direct and indirect government measures in the areas of government and industry coordination, technology development, financial assistance, and market protection.

- The prospects for the future are uncertain but continued Japanese advances are likely. The U.S. industries are probably capable of deflecting the near-term challenge but the competitive process will limit profits and at the same time require large investments in both R&D, and plant and equipment. As a consequence, if adequate and low cost external capital is not available, the rapid pace of U.S. industry innovation may decline and open the doors for further competitive inroads by the Japanese or others with access to an adequate supply of capital.

The problem then is to determine how the United States should respond to the Japanese efforts to create a competitive advantage in the key high technology sectors on which our industrial future rests.

This problem is just one of the problems currently facing U.S. industries. Similar problems face the automobile industry, the steel industry, the machine tools industry, the petrochemical industries, and a host of others that are under competitive pressure from the Japanese, the Europeans, the Newly Industrialized Countries (NICs), and (in the case of petrochemicals) the OPEC countries. It can be argued, however, that the high technology industries such as computers, are different and more important because they will support competitiveness in all sectors, because they have military significance, and because they are consistent with the role of an advanced economy such as the U.S. in the interdependent and rationalized world economy of the future.

In the next section, proposed policy responses are described and discussed.

VIII. OVERVIEW OF PROPOSED POLICY RESPONSES

The major role in responding to the Japanese challenge will be played by the U.S. computer and semiconductor firms and their employees as they develop corporate and industry responses to the evolving competitive situation. Under normal circumstances, these firms would prefer the least possible amount of government interference in the domestic market except for government's traditional and necessary role in formulating and executing international trade policy. A laissez-faire policy of this type would also be philosophically consistent with the advocacy of a reduced role for government and greater reliance on the free-market by the current administration. Why, then, have a number of authors[53] advocated that the US develop and implement a coherent industrial policy that could support efforts to respond to the challenges posed by the increasing competitiveness of the Japanese and others in both high technology and other industries? The arguments advanced in favor of such a policy are:

- Our present approach does not rely only on the market. We already have an ad hoc industrial policy, with decisions largely based on politics rather than reasoned analysis.
- Today, the U.S. no longer enjoys the overwhelming technological lead or relative economic strength it possessed two or three decades ago. As a consequence, government responses to the Japanese threat may be required in a number of policy areas. Wouldn't it be advantageous to embed these actions in a coherent framework rather than consider them in a piecemeal fashion?
- A consciously developed industrial policy need not imply centralized control.
- An industrial policy is needed to assure a continuing supply of strategic resources; accelerate positive market trends; reduce waste; promote efficiency; anticipate shortfalls in supply and injurious perturbations; create a climate of certainty, reliability, stability; and to facilitate structural adjustment.

The arguments against such an approach relate to questioning the need for any significant government intervention and questioning the ability of government to either reach a consensus on a well-reasoned policy approach or implement a chosen approach with any effectiveness. Whether or not we have an implicit or explicit industrial policy, a conceptual framework would be helpful for evaluating the policy alternatives that have been proposed.

The areas of policy concern include:

- Steps for improving the policy development process;
- Trade policy; and
- Policies for enhancing US competitiveness.

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[53] See Gresser, p. 42-47, and OTA report, p. 19.

Steps for Improving the Policy Development Process

The following have been proposed:

1. Create a central focus in Congress for members and staff with responsibility for policies that affect industry.[54]

2. Encourage broadly based government, business, and public participation aimed at clarifying the goals and objectives of industrial policy.[54]

3. Create an analytic group with ongoing responsibilities for examining competitiveness and economic performance and their relationships to productivity; technology; and regulatory, tax, and trade policies. Such a group might include projections and forecasting among its responsibilities.[54]

4. Establish a body in the office of the President that would have responsibility for the coordination of industrial policy throughout the government.[55]

Comment: The arguments favoring an attempt to better define an industrial policy for the US are persuasive to the author and the above appear to be prudent, albeit minimum steps in support of that goal. The author has found only a small number of government people working in this area and they are scattered around the government. Consequently, the depth and quality of the data base and policy analysis currently available to policy makers is less than adequate. Greater attention to data collection and analysis--both foreign and domestic--would also be needed to support the recommended analytic group and other policy-making bodies.

Trade Policy

As previously discussed, a number of authors have argued that domestic market protection through both formal and informal barriers has been a key element in the success of the Japanese computer and semiconductor industries.[56] This protectionism provides a financial cushion that can be used to support foreign market penetration via aggressive pricing and can limit the size of markets available to U.S. firms thus denying them economies of scale. Zysman has argued that recent Japanese trade liberalization actions have not significantly altered the "informal" protectionism in their semiconductor market. Thus, the Semiconductor Industry Association (SIA) and the Computer and Business Equipment Manufacturer's Associate (CBEMA) have made statements in favor of expanding freely determined fair trade and investment and have made a number of specific recommendations against protectionism in the US market and in favor of vigorous attempts to open up both Japanese and European markets.[57]

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[54] OTA, p. 8, 9
[55] Gresser, p. 54-56
[56] For example, Zysman, Gresser.
[57] See CBEMA Trade Statement, Lidow's testimony, CBEMA 4 February 1982

The issue of foreign barriers to U.S. exports and investment has been widely reported in the press because of recent high level trade talks with the Japanese and Congressional interest in new "tougher" trade legislation. The Wall Street Journal reported in March 1982:

> "And there's a serious possibility that Congress could embark on a full scale protectionist spree. So far this year, lawmakers have introduced some 19 trade-restriction bills, ranging from mild measures to a proposal by Rep. Fred Richmond, a New York Democrat, that would slash Japanese exports to the U.S."

The administration has opposed more specific "reciprocity" bills that would mandate US retaliation in certain industries and has agreed with Congress to seek a compromise that conforms to international trade rules. The compromise bill would, at a minimum, provide that the President be granted broad new authority to: (1) negotiate with other countries new rules governing international investments and trade in services, which aren't covered under GATT; (2) negotiate substantial tariff reductions as part of an effort to liberalize restrictions on high technology exports.

Mr. W.J. Sanders, testifying to Congress on behalf of the Semiconductor Industry Association recently endorsed the High Technology Trade Act S. 2356,

> ". . . I would urge in the strongest possible terms that the High Technology Trade Act, S. 2356, introduced on April first by Senators Hart, Heinz, and Cranston (cosponsored by Senator Mitchell) before your committee now, be made an integral part of the legislative solutions that you provide. . . .
>
> Its goal is to obtain maximum openness of international markets to high technology trade and investment, through negotiated agreements directed at eliminating existing barriers. It has as its objective that U.S. companies exporting to or investing in foreign countries will receive national treatment. The bill would also establish a monitoring system to measure the degree of openness of foreign markets, and would strength the international trading system through more rigorous use of existing procedures under U.S. laws and trade agreements."[58]

The provisions to be included in new trade legislation and prospects for its passage this year are uncertain. Informed observers, however, feel that the more extreme reciprocity bills will probably be rejected and a moderate bill consistent with the High Technology Trade Act is the most likely outcome. Even if such a bill is passed, its benefits may be minimal and slow in coming. Some argue that the President already has adequate authority to

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58 Wall Street Journal, March 23, 1982; Sanders testimony, May 6, 1982, p. 2 and 7.

proceed under existing law. The relatively slow progress that has been made in the current negotiations with the Japanese on non-tariff barriers is an indication of deep and fundamental differences on this issue between the U.S. and Japan and the reluctance of both parties to have the dispute escalate into a full-fledged and acrimonious trade war. Others argue that the U.S. has been too soft in both negotiating and enforcing trade agreements. In this view, a congressional mandate for negotiations and potential executive branch action would be helpful in convincing our trading partners to reach equitable agreements for reducing barriers to U.S. trade and investment.

Encouragement of U.S. exports, another area of interest, is probably of less importance in the computer and semiconductor industries but the industry associations (CBEMA, and the Electronics Industry Association) have supported the following measures:[59]

- Foreign Corrupt Practices Act: Advocate unspecified weakening under the rubrics of "remove defects" and "eliminate ambiguities".

- Export Trading Companies Act: Support the intent of H.R. 1648 to encourage export trading companies including appropriate revisions to antitrust laws.

- Export-Import Bank: Support continued and increased funding of the EX-IM bank to meet foreign competition while continuing to bring pressure to bear for elimination of subsidized government financing of exports.

- Export Controls: Modify current policy (Export Administration Act of 1979) and administration to eliminate unilateral controls (those without the support of our allies), control only militarily significant technology, and simplify and expedite licensing.

Comment: The trade policy issue is vitally important but the appropriate U.S. policy direction is not at all clear. Protectionism, both formal and informal, is likely to continue and possibly even increase despite the best efforts of the U.S. The worldwide recession and fundamental changes in the world economy (e.g. the emergence of the NICs) are forces pushing national economies toward greater protectionism. U.S. economic leverage, although powerful, must be used sparingly because undesirable escalating actions could be the result. For these reasons, we favor some form of moderate trade legislation but recommend against any "heavy-handed" approach. The President should be given the authority to use appropriate remedies consistent with our multilateral trade agreement obligations but he should be given wide latitude in his selection of the appropriate remedy. Provisions to establish a monitoring system to measure the degree of openness of foreign markets will also support the selection of appropriate policy responses. We doubt that new trade agreements will, by themselves, solve the problem. Policies for enhancing U.S. competitiveness (see next section) must be pursued as part of a two-track approach.

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[59]See CBEMA, February 1981 and December 1981, & EIA, December 16, 1981

The arguments in favor of expanded EX-IM bank funding appear to be valid. The arguments against export controls, however, must be carefully reviewed in the context of the known national security technology transfers that have occurred in recent years.

Policies for Enhancing U.S. Competitiveness

Policies for enhancing U.S. competitiveness in the computer and semiconductor industries can be considered in four broad categories:

- Manpower Policies
- Tax and Capital Market Policies
- Research and Development Policies
- Government Procurement Policies

Manpower Policies: In the area of manpower, the major problem noted has been the current shortage of high technology manpower--electrical engineers and software engineers--and projections for an increasing gap between the demand and supply of these types of engineers.[60] The statistic most often cited is that Japan, with half the population of the United States, is now graduating more electrical engineers than the United States. Dr. William Perry, former U.S. Under Secretary of Defense for Research and Engineering, has said:

> "In spite of some who claim otherwise, the shortage of engineers is real. Such shortages pose a serious threat to national security, where technology helps the U.S. maintain the balance of world power; to our economy, where high technology shines as a bright spot, and to the continued vitality of electronics industries, where the lack of electronic and computer science engineers may be the single most important factor limiting growth."[61]

The Reagan administration's Economic Recovery Tax Act of 1981 recognized the need to encourage industry to invest in plant, equipment and R&D in order to stimulate growth and enhance U.S. competitiveness. However, they have not recognized the need to take action to address the lack of electronic and computer science engineers referred to by Dr. Perry. Denis Doyle, Director of Education Policy Studies at the American Enterprise Institute, writing on the op-ed page of the March 10, 1982 Washington Post, made a more sweeping argument:

> "We are now confronted with a pressing need to revitalize America. The common thread is human capital, the

[60] See, for example, Zysman, p. 164; OTA, p. 90; Report on Trade Mission to Far East, p. 35

[61] AEA Technical Employment Projection, p. 1 of Introduction

educated men and women who will make the wheels of post-industrial democracy turn. We face a real crisis in math, science, computer science, and foreign language education. . . .

The crisis is upon us, and it is being compounded by the administration's decision to further reduce higher education spending, without proposing a workable alternative. This is precisely the time when increases in human capital investment are most needed. It takes 20 years to train the next generation of engineers, scientists, and linguists."[62]

Shortage of Electrical Engineers and Computer Scientists: Electrical and computer science engineers make up the bulk of the engineering work force in the computer and semiconductor industries. The two disciplines overlap to a degree and in some colleges these disciplines are taught in the same department making it difficult to sort out the precise supply of each specialty. The American Electronics Association (AEA) has projected demand to be about three times as great as supply for these types of engineers in the U.S. electronics industries as shown in Table 8.[63] The demand projection is based on scaled data from an AEA survey of 671 facilities with annual sales of $77.7 billion. The supply projection is based on extrapolations of recent trends. The National Science Foundation (NSF), using a different methodology in a 1980 study, concluded that over the twelve years from 1978-1990 demand would be 670,000 versus a supply of 282,000-365,000 graduates (see Table 9).[64] The AEA demand projection, inasmuch as there was no attempt to constrain the total of the individual company estimates based on an aggregate industry growth in sales, is likely to be on the high side. On the other hand, the NSF econometric modeling would probably fail to capture major technological changes such as those that are occurring in the computer and semiconductor industries.

Regardless of which projection is more accurate, both seem to agree in forecasting a major shortfall in the supply of these types of engineers over the next 5-10 years. A major ameliorating factor, however, is that many new graduates, at all degree levels, choose to enter fields different from those in which they were educated.

"Such mobility across disciplines reflects market conditions in the chosen field of employment relative to the field of training as well as personal preferences. . . .By this measure, there has been a marked shortage of degree recipients in the computer professions."[65]

[62]Doyle
[63]AEA Plan for Action, p. 7
[64]NSF 80-78, p. 26-31
[65]Ibid, p. 25-26

Table 8

AEA Projection for Electrical & Computer Engineers
in US Electronic Industries
(5 year period 1981 - 1985)

	BS (Electrical Engr.)	BS (Computer Science)	Total
Job Openings	125,000	73,000	198,000
Supply of Graduates	59,000	10,000	69,000

Table 9

NSF Projection for Employment of Electrical &
Computer Engineers in the US
(12 year period, 1978-1990)

	Electrical Engineers		Computer Science Engrs		Total
	BS	MS	BS	MS	
Job Openings	.....121,000....		........549,000.......		670,000
Supply of Graduates	172,000	36,000*	110,000	47,000	282,000-** 365,000

* Estimate based on proportion of BS/EEs to all BS/engineering and total number of engineering MS degrees.

** Most of the MS graduates are probably already counted in the BS figure. Thus, the lower figure is probably more accurate.

Mobility from other scientific and engineering fields into the computer professions can be expected to continue because a 1978-1990 oversupply has been projected for many of the closely related professions, e.g., mathematical sciences - 83,000, physical sciences - 202,000, engineers (other than EEs) - 349,000.[66] What fraction of this excess supply of 634,000 would actually change to the computer professions is not known but it can be expected to reduce significantly the projected shortage provided there exist sufficient resources to retrain these individual for the computer and electrical engineering professions.

The AEA has concluded that "the shortage of BS degrees is primarily due to a lack of resources, especially faculty, of engineering colleges to handle the oversupply of qualified students."[67] AEA further states that the applicant-to-admission rate is about 3-1, implying an appalling undersupply of educational resources if all of these applicants were qualified and if each applicant applied to only one school. Nevertheless, even if the 3-1 estimate is an overstatement, there appears to be agreement with AEA's basic premise. Paul Gray, President of MIT, recently said:

> "The engineering education system is saturated. Expansions of capacity cannot occur without adding to the faculty ranks."[68]

Shortages in faculty are ascribed primarily to low teaching salaries compared to those for scientists and engineers in industry. Other factors cited are higher student-faculty ratios and inadequate facilities and equipment for research.[69]

AEA's plan for action is:[70]

"I. Expanded educational resources

- A. Increase faculty
  - AEA adjunct and visiting professors
  - AEA teaching "chairs"
  - AEA industry consultancies (salary supplements for new faculty)
  - Legislative action to increase engineering and computer science faculty salaries (public universities)
- B. Increase and upgrade equipment and facilities
  - AEA grants
  - AEA equipment transfers
  - Legislative action to increase equipment/facilities budgets (public universities)

II. Increase graduate student supply (more Ph.Ds)

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[66] Ibid, p. 29
[67] AEA Plan for Action, p. 1
[68] Paul Gray speech
[69] AEA Plan, Paul Gray speech
[70] AEA Plan, p. 3

A. AEA graduate student fellowships

B. AEA co-op programs"

Tax changes to encourage industry to provide such support to universities have been proposed (see next section).

The AEA proposals are consistent with NSF's earlier recommendations for a non-federal approach:

> "While there can be important Federal contributions toward alleviating the shortage of engineering and computer professional faculty, we believe that universities and industries must assume the primary role in this area. Universities increasingly recognize the special research needs of their engineering and computer professional faculties. Some are considering the appropriateness of a medical school model for engineering schools, whereby faculty members would be allowed more liberty to supplement their salaries and gain access to specialized research facilities in industry. Industry also can take several steps to respond to the shortage of faculty. It can, for example, form consortia to support university research groups; or offer money, equipment and personnel in exchange for university-conducted research. It can make its unique research facilities available to university faculty. Industry can provide support to universities which would in turn offer continuing education to its engineers. It can offer cooperative arrangements so that university faculty members can engage in industrial research while industrial engineers serve in university departments.
>
> Finally, industry can join with universities to create work-study programs at undergraduate, graduate and post-doctoral levels."[71]

However, NSF did recommend some direct, short term Federal assistance:

- Greater federal support for purchases of research equipment and equipment for undergraduate instruction.

- Special fellowships for PhD candidates interested in university teaching.

- Review of tax, patent, copyright and antitrust laws to encourage industrial support.

[71] NSF 80-78, p. 9

The programs recommended by AEA and NSF assume the existence of an adequate supply of qualified applicants. However, there are some reasons to believe that the supply may not be adequate:

- The supply of 18 year olds is going down (from about 4.2 million in the 1977-1980 time frame to about 3.7 million in the 1983-1989 time frame)

- The quality of preparation of high school graduates for careers in science and engineering is declining. (Evidence cited is the long-term decline in SAT scores and the lack of availability of math and science courses in the curricula of many high schools.)[72]

- The continued high attrition of engineering students (the percent of graduates to incoming freshmen four years earlier has increased from 50% in the 60s to close to 70% in 1981. This suggests - assuming standards have not been relaxed - that the overall qualifications of those admitted may now be higher than previously but that there are still a large percentage who are poorly prepared).

- The unknown effects of the planned reductions in the government student loan program. (This will probably affect colleges in an uneven way. Demand at relatively inexpensive public institutions will probably increase while private colleges--particularly those outside the highest ranks--are likely to see a marked decline in qualified applicants.)

Policy initiatives that would address the quality of preparation issue have been proposed in the NSF study and include:[73]

- Programs to increase public awareness of the need for excellence in science and technology through a variety of councils, committees, etc.

- Federally sponsored curricula development programs for stimulating interest in science and technology.

- Federally sponsored efforts to develop and stimulate the use of approaches for using new technologies (computers, video recording) in science and mathematics instruction.

- Measures to alleviate the serious shortage of qualified mathematics and physical science teachers. (No solution to the primary problem--low salaries--is proposed. However, approaches for improving laboratory facilities, in-service teacher training, and teacher support systems have been proposed.)

- Measures to increase awareness of career opportunities in science and technology.

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[72] Paul Gray speech
[73] NSF 80-78, p. 3-7

All of the above were recommended in support of a different goal, the goal of improving science and technology education for all Americans. NSF argued that reaching this goal was important because, "Today, people in a wide range of non-scientific and non-engineering occupations and professions must have a greater understanding of technology than at any time in our history."[74]

Qualified students who can afford to go to college will undoubtedly be attracted to science and engineering (vice other majors) if the job market and salaries for graduates remain strong. If student aid is cut, it will be a disincentive for attending college. Financial aid--federal, state, or private --that is targeted toward preferred fields of study such as science and technology is an intermediate alternative that would stimulate the supply of qualified students in these fields.

Another alternative for addressing the shortage of electrical and computer science engineers is to seek better ways to use and upgrade the skills of engineers employed in industry. Alic, Caldwell and Miller, in discussing the role of engineering education in industrial competitiveness, point out that the American system contains disincentives working against industrial sponsorship of continuing engineering education,

> ". . . continuing engineering education in the United States is centered in industry, with universities by-and-large playing a marginal role. Even so, the frequency with which Americans change jobs--often moving to competing firms in the same industry--works against training and education programs sponsored by employers, because the investment can easily be lost and may end up benefiting competitors. Greater employment stability characterizes engineering work forces in other countries, particularly Japan, and makes it easier for employers to justify education and training for engineers as well as for workers in other job categories."[75]

Alic does not offer specific policy initiatives. However, if job mobility is indeed a disincentive to such training by industry, it would appear that government action to stimulate such training--such as grants or tax credits--would be necessary.

<u>Shortage of Technicians and Skilled Production Workers</u>: A shortage of highly-skilled technicians and production workers has also been cited as a related general U.S. problem. This situation is expected to become more serious as the use of robots reduces the need for unskilled labor. Japanese labor adjustment policies that emphasize worker retraining have been noted as an approach that should be considered for application to the U.S.[76]

<u>Japanese Studies</u>: It has been noted that Japanese management, particularly related to worker relations, and production quality and cost, may

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[74] Ibid, p. 3
[75] Alic, p. 27
[76] <u>Report on Trade Mission to Far East</u>, p. 36

be superior to that of U.S. firms.[77] Although government can probably do little about this problem, it can support study of the issue, and specifically, promote education for civil servants in Japanese studies (HR 4346).[78]

<u>Comment</u>: The administration has taken steps to reduce the federal government's role in education but, according to Chester Finn, Professor of Education and Public Policy at Vanderbilt University,

> "[The Reagan administration's energies and attention have not been devoted to] figuring out how to improve what is taught and learned in schools and colleges, how to make them efficient and effective institutions, and how--if at all--the federal government can appropriately assist in that important national undertaking."[79]

The administration view is apparently that education is primarily the function of state and local governments, industry and the private educational institutions. Whether or not these other institutions can cope with the problems discussed above is questionable. If it is correct that our national future depends on improving our educational system for science and technology, then the administration should take steps to lead and coordinate the efforts of all elements of the educational system, and see to it that federal education expenditures are directed toward supporting that goal.

<u>Tax and Capital Market Policies</u>: The availability of stable low-cost capital is vital to both the computer and semiconductor industries because of their need to respond to continued technological change and rapid growth in markets. The Japanese economy has been able to provide such financing to their industries; the U.S. economy has been deficient in terms of both stability and cost.[80] The Reagan administration's tax program recognized this problem and the Economic Recovery Tax Act of 1981 contained a number of provisions for:

- Encouraging personal saving and investment (lower personal tax rates and capital-gains rates, IRAs, all-savers, tax-exempt dividend reinvestment for utilities, liberalization of taxation on stock options, etc.).

- Encouraging businesses to invest in plant, equipment, and R&D (liberalized depreciation rules, R&D tax credit for increases in R&D spending, liberalization of code 861 encouraging the conduct of R&D in the U.S., etc.).

Nevertheless, the cost of borrowing has remained high because of factors such as the Federal Reserve's tight money policies and the requirements of the Treasury to borrow to finance the burgeoning federal deficit. Equity

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[77] Ibid, p. 41-45
[78] Ibid, p. 35
[79] Finn.
[80] See Zysman, p. 160-162, Gresser p. 47

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financing has been equally unattractive because of the recession-induced stock market slide. However, in the long run--if the federal deficit can be controlled--the administration's policies to stimulate business investmentshould have their intended effect. Specific tax issues of current interest to the computer and semiconductor industries include:

- Depreciation: High technology equipment was already written off in a relatively short time. Consequently, liberalization to 10-5-3 had limited direct benefits for these industries. SIA advocated a short-lived equipment write-off of two to three years with a full investment tax credit.[81]

- Tax Credit for Increased R&D: This provision to stimulate additional R&D spending will result over the next five years in estimated savings to all U.S. industry of one to two percent of R&D spending and might, for example, amount to as much as 200-400 million dollars for the semiconductor industry. The House Ways and Means Committee's Subcommittee on Trade has recommended hearings and further study of this issue to determine if this degree of financial support is adequate.[82]

- Deduction for Contribution to University Research: SIA advocates that the tax credit for contribution to university research be separated from the existing R&D credit and be granted on an absolute rather than incremental basis. It also proposes liberalization of rules for corporate contributions of equipment.[83]

All of the above measures apply equally to all U.S. industries even though their benefits may turn out to be greater for one industry compared to another. Zysman, however, argues that:

> "some form of targeted tax legislation, aimed not at a particular sector but at growth sectors in general, may be required to modulate the effect of business downturns on the industries that will fuel growth."[84]

This sectoral approach was also discussed earlier by Gresser but he stopped short of an endorsement.[85] If Zysman is correct and "the struggle for capital may emerge as a battle between the existing industrial structure and the need to prepare for America's industrial future", it appears that the existing industrial structure is winning this stage of the battle.[86]

Research and Development Policies: Technology, applied to products through research and development, has been the key to U.S. domination of the computer and semiconductor industries. As the result of wide diffusion of U.S. developed technology and vigorous Japanese government-industry efforts,

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[81] See SIA Yearbook, p. 19
[82] Report on Trade Mission to Far East, p. 32
[83] Lidow, p. 9
[84] Zysman, p. 163
[85] Gresser, p. 47,48
[86] Zysman, p. 164

the once huge U.S. technological lead over the Japanese has been lost and the Japanese are at or near technological parity with the U.S. in many segments of the computer and semicondutor industries. If these U.S. industries are to survive the challenge, they must continue to innovate and move technology forward because the Japanese are not likely to be defeated in high-volume production of a slowly changing product.[87]

One key aspect of R&D--its financing--was discussed in the previous section. Other aspects include:

- Direct Government Funding

- Cooperative R&D and Anti-trust Policies

- Patent Policy and the Transfer of Technology

Direct Government Funding: Direct government funding of R&D was an important factor in the early development of the computer and semiconductor industries but has been relatively insignificant over the past 10-15 years. In 1980, the Department of Defense (DoD) initiated a program in applied semiconductor research known as the Very High Speed Integrated Circuit (VHSIC) program. VHSIC is a six year program for both research and procurement with total funding of about $300 million and it has relatively narrow military goals. VHSIC may also have a largely unplanned beneficial effect on the U.S. industry's commercial competitiveness.[88]

Other elements of DoD and other government agencies conduct research in computer and semiconductor technology; for the most part, such research is narrowly directed toward agency-specific goals rather than commercial applications. Basic research is, however, supported by the Defense Advanced Research Projects Agency (DARPA), the Office of Naval Research (ONR) and the National Science Foundation (NSF). The government sponsored research seems to fall at both extremes, basic R&D and agency-specific applications work. The author is unaware of any program of direct government funding of R&D directed at commercial applications. Gresser and Zysman discuss such a program but do not vigorously endorse one.[89] There is no support for such a program presently coming from either Congress or the Industry Associations.

Cooperative R&D and Anti-Trust Policies: A major reason cited for the effectiveness of Japanese R&D is their ability to eliminate overlap and duplication by fostering industry cooperation in carrying out the program. In the past few years, firms in the U.S. computer and semiconductor industries have taken steps to follow the Japanese example and form cooperative R&D ventures. SIA, for example, has organized within its membership a joint industry-university research program intended to supplement the efforts of individual companies. The joint project, a non-profit endeavor financed primarily by contributors from participating

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[87] Rubinger.
[88] Charles River, p. 151-155, 143-144, 174-176, VHSIC Notes, p. 3
[89] Gresser, p. 49, Zysman, p. 158.

private firms, will be directed at long-term science related projects.[90]

A similar project for the computer industry has been proposed by Mr. Robert Price, president of Control Data Corporation. Price proposed that the venture should perform research, development and production in semiconductor technologies and projects. The products, however, would beprovided to its shareholders, not to the "merchant" market. The entity would serve as an umbrella organization to fund long-term R&D, arrange for manufacture or set-up its own manufacturing capability, and could also help focus the support for University research programs.[91]

The SIA cooperative research program might have a yearly budget of some $40 million/year; the cooperative effort proposed by Price might require $100 million/year for R&D and, possibly, an equivalent sum for capital expenditures for production facilities. Direct government involvement is not envisaged for either entity; however, tax benefits for contributions to university research would be helpful (see previous section). A key issue is whether or not such ventures violate U.S. antitrust laws and, if so, whether legislation to amend these laws is needed. OTA has concluded that,

> ". . . cooperative R&D programs . . . may continue to be challenged under antitrust provisions--by the Government or by private parties. The guidelines for joint R&D recently issued by the Department of Justice . . . seem unlikely to have a dramatic effect on perceptions in this areas."[92]

EIA apparently agrees and has proposed that, "The antitrust laws would be amended in order to provide that companies operating within the scope of an approved business review letter would be immune from civil and criminal antitrust action for activities within the scope of the approval."[93]

Comment: Concerns about antitrust violations are evidently not high enough to stop cooperative R&D efforts but they may be slowing these efforts down and constraining the approaches that are chosen. Cooperative R&D appears to be a preferred policy response and should be supported by appropriate government actions, including new legislation if that is required. Quoting Mr. Robert Price,

> "Either the U.S. computer industry will adopt a strategy of broad technological cooperation or it won't. If it does, there will be vitality and growth. If it does not, there will be isolation and sickness. IBM will be the General Motors of the 90's. The rest of us won't even have to worry about it."[94]

[90] Zysman, p. 157.
[91] Price Speech, April 1981.
[92] OTA, p. 185
[93] EIA 16 December Statement, p. 2
[94] Price Speech, April 1981

Patent Policy and the Transfer of Technology: Investments in R&D will pay off to the investing firm only if it can keep the knowledge so obtained from competitors that seek to appropriate the knowledge for their own use without adequate compensation. On the other hand, the "public good" is furthered and the state-of-the-art is rapidly advanced if the findings of research are diffused rapidly to the industry. The balance between these competing interests is delicate.

In the computer and semiconductor industries technological know-how has become widely diffused by mechanisms such as:

- Licensing of patented inventions: The investing firm may receive compensation in cash or, alternatively, exchange the use of its patents for the use of those of the other firm (cross-licensing). It has been reported that the Japanese government imposed licensing requirements on IBM and Texas Instruments as a condition for entry into the Japanese market and that other firms elected to license their patents when denied entry to the Japanese market.[95] (Some have questioned whether or not it is fair to state that the Japanese government imposed licensing requirements on IBM and Texas Instruments but agree that the government was intimately involved in the issue of licensing--i.e., what would be licensed and to whom.) In practice, the patent system has functioned poorly in these high technology industries because the infinite variability of solutions to technical problems in the industry means that rivals may appropriate much of the value of a new invention disclosed in a patent without legally violating it.[96] It is also noted that software is presently almost impossible to protect; programs typically cannot be patented and copyrights can be easily circumvented.[97]

- Reverse engineering: A product can be procured (purchased on the open market or otherwise obtained) and analysed to determine its design and principles of operation. If not protected by patent, it can be copied.

- Open literature: Basic research findings are reported in scholarly journals, scientific conferences, and informal contacts.

- Other techniques: Other approaches include: joint ventures and acquisitions, hiring of key people, and industrial espionage. Such techniques would be used to determine unpatented design and manufacturing trade secrets which would be otherwise unobtainable.

There are two principal questions:

- Are there barriers to the flow of Japanese technology to the U.S. industry that give Japanese firms an unfair advantage over competing U.S. firms?

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[95] Gresser, p. 9, 11
[96] Zysman, p. 155
[97] OTA, p. 155

- Is the diffusion of technology too rapid for the U.S. industry to remain viable, given the proven Japanese capability for high volume production with low cost and high quality?

The answer to the first question may be yes because, for example, U.S. firms maintain that they have not been given full access to the results of the Japanese VLSI project.[98] Equal national treatment is one of the major goals in our bilateral trade negotiations with Japan. If this is obtained, inequalities in the diffusion of technology should be eliminated.

Answering the second question is much more difficult. The diffusion of technology in the semiconductor industry has been very rapid indeed but, until now at least, industry leadership has gone to the major innovating firms. Today's situation vis'a vis' the Japanese may be different. A study of this question, including alternatives--such as a technology transfer tax--for slowing the technology flow, should be carried out.

There are no specific proposals in this area from either Congress or the industry associations. Lesnick pointed out the threat posed to U.S. industry by technology transfer to the Japanese. He has recommended that industry police itself to guard against this flow and pointed to some of the technology transfer risks associated with joint ventures in Japan and Japanese-owned U.S. banks.[99]

Another important related question is whether or not U.S. firms are being adequately compensated for their technology sales. If U.S. firms could collaborate to deal as monopolists with Japanese buyers of technology, a higher return might be obtained.

Government Procurement Policies: The Department of Defense and NASA played a major but largely unplanned role in the development of the semiconductor industry through their purchase of equipment for military and space applications. In 1958, for example, 35% of the dollar value of semiconductor sales had a military end use; in 1979, the comparable figure was 10%.[100] DoD, NASA, and other government agencies played a similar role in the development of the computer industry. Specific figures on the government share of the computer market are not available but are probably comparable to those for the semiconductor industry. U.S. procurement regulations for computers and semiconductors are generally less restrictive than those of other countries regarding discrimination based on country of origin or percentage of local content. However, special rules for the protection of classified information in connection with the procurement of hardware for the Department of Defense also serves to limit foreign access to the government market. The Wall Street Journal recently reported that the Defense Department was proposing some form of sanctions designed to thwart Japanese domination of the U.S. market for 64K RAM chips because of fears that such domination could leave the military vulnerable if war broke out. Such actions could be taken under a rarely used section of U.S. trade law that allows the President to restrict imports that are found to be jeopardizing national security. Although the report stated

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[98] Zysman, p. 131, 132
[99] Lesnick, p. 4,5
[100] Charles River, p. 19

that the form of sanctions to be employed "isn't clear yet," it is not unreasonable to assume that the Defense Department might favor a "Buy-American" policy for semiconductors that are contained in defense weapons systems.[101] The author is unaware of any support for such a move from Congress or the Industry Associations. Supporting industry through government procurement is likely to be ineffective, except in those segments--e.g., very large scale scientific computers--where government represents a major share of the market.

[101] Wall Street Journal, Feb. 5, 1982

APPENDIX

Organizations and Persons Consulted

Government	Persons Consulted
CIA	Office of Global Issues
	Office of Scientific & Weapons Research
Commerce Dept.	William Finan
	Norm McLennon
	Tim Houser
	Marjory Searing
	John McPhee
	Tim Miles
	Mike Kubiak
Defense Dept.	Don Burladge
	Paul Losleben
International Trade Commission	Ross Reynolds
	Nelson Hogge
	Bill Fletcher
Special Trade Representative	Jim Murphy
Congressional Staff	David Rohr
Office of Technology Assessment	Martha Harris
	John Alic
GAO	Margaret McGregor
State	Joe Hayes
Non-Government	
Harvard University	Professor Theresa Flaherty
	Andrew Osterman
Massachusetts Institute of Technology	Professor James Bruce
	Professor Richard Samuels
Brookings	Phil Trezise
Industry	
Wang Labs.	Ed Lesnick
IBM	Aaron Cross
	Ken Richeson
Computer & Business Equipment Manufacturers Assoc.	Lloyd Kaufman
Transportation Systems Center	Bruce Rubinger
Mitre Corp.	Ron Haggarty
V.L.B.M.	Mike Gadbaw

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